INVESTIGATIONS IN CHEESE-MAKING.

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The experiment reported in the following pages was undertaken on the suggestion of Prof. Wilson, Director of the Experiment Station, and carried on during the spring of 1893. Among the things studied during the investigation were the following:—1. The amount of the cheese constituents of the milk lost during the process of manufacture. 2. The relation between the amount of fat in the milk from which the cheese was made and the loss of fat during the process of manufacture and afterward. 3. The relation between the amount of fat in the milk and the amount of cheese made from it. 4. The comparative cost of production and the final market value of cheese made from milk containing different per cents of fat. 5. The ripening of cheese made from milk containing different percentages of fat. In addition the chemist to the station is making a study of the chemical changes that take place in the cheese made during this experiment.

The greater number of the cheese were made by Mr. G. L. McKay, a few being made by the writer and by Mr. F. A. Leighton. The analytical work was done under the direction of Prof. Patrick, chemist to the Experiment Station.

In order that the experiment may be more intelligible to the reader, and with the hope that it may be helpful to the cheese-makers of the state, some little space is devoted to the principles which underlie the science of cheese-making, the object being not to write a treatise on the subject, but to call especial attention to the most important steps in the process and to emphasize the necessity for skilled labor.

DISCUSSION OF THE PRINCIPLES INVOLVED IN CHEESE-MAKING.

Ripening the Milk.—The development and management of acid is the most salient feature in the manufacture of cheddar cheese. This is, perhaps, the chief reason why the cheddar method has been so generally introduced in this and other countries; the development and control of acid according to certain well established principles making it possible to produce cheese of about the same uniform quality under varying natural conditions and in different countries. As is now generally known, the acid in milk is produced by minute organisms called Bacteria, which gain access to the milk immediately after it is drawn from the cow's udder and multiply with marvelous rapidity. The acid is produced by the action of these organisms, or germs as they are more commonly called, upon the milk sugar, causing it to change to lactic acid. It should be noted that not all of the germs found in milk are capable of producing acid, but there always is a sufficient number of those that are. The first step in the development of acid by the cheesemaker is when he "ripens" the milk in the vat before introducing the rennet. By the term "ripen" we mean allowing the milk to develop a certain amount of acidity, to proceed a certain distance toward souring. It has been found by experience that it is best to have a certain amount of acid in the milk before the introduction of the rennet; there are several reasons for this. When the milk is ripened to a certain degree before the rennet is added time is saved for the maker, because it does not take so long to develop the required amount of acid in the after process. Agan, the acid helps to expel the extra whey and thus gives a firmer, stiffer curd. The main reason, however, why it is better to ripen the milk will probably be discovered when the truth is known as to the relation between the rennet on the one hand and the germs which cause acidity on the other; there is as yet very little known about this.

It is evident to any person who has practical knowledge concerning the manufacture of cheese that there is danger in developing too much acid before the rennet is added. To make good cheese the acid must always be under the control of the maker; if it be allowed to get too great a start in the milk it passes beyond his control, and he must hurry the process as rapidly as possible and get the curd in the press before too much acid is developed. The result is a heavy loss of fat in the whey, and the cheese is of poor quality, curing imperfectly and giving poor satisfaction to both maker and consumer. In order to know the kind of milk with which he has to deal the maker should apply a test to ascertain its ripeness as soon as it is heated up to eighty degrees. The most satisfactory method of determining the ripeness of the milk at this point is by means of a rennet test. While a maker who has a delicate taste and smell and who has had long experience in the business can determine the condition of the milk pretty accurately without any test, the most satisfactory way, both for beginners and makers of experience, is to use a test of some kind, and the latter are becoming so common now that most cheesemakers are familiar with them. We have used what is known as the Monrad test with very satisfactory results; it is on the same principle as other rennet tests, but we think a little more sensitive.

If the milk is sweet and in good condition when it comes to the factory the temperature should be raised slowly. Rapid heating injures milk, and while it is sometimes necessary, as when the milk is too ripe, it should always be avoided when possible. While the temperature is being raised the milk should be gently stirred at frequent intervals with a view to equalize the temperature and prevent the cream from rising. The stirring must be done gently. Violent agitation when the milk is warm partly churns some of the fat, which shows itself on the surface in the form of white clots. The main object is to keep the fat as evenly distributed as possible, so that it will be caught and held by the casein when the latter is coagulated by the rennet.

Adding the Rennet.—As before noted, the rennet test indicates when the milk is in proper condition to receive the rennet. The amount of rennet to use depends upon the season of the year, the length of time in which it is desired to market the cheese, the strength of the rennet and the condition of the milk as regards ripeness. For this reason it is impossible to say just how much rennet should be used. Each maker must determine that for himself according to the conditions which surround him. In general it may be said, that enough rennet should be used to coagulate the milk fit for cutting in thirty to forty-five minutes. The rennet should be carefully measured in a graduated flask and diluted with water of the same temperature as the milk; this makes it easier to secure even distribution. The temperature at which the milk should be when the rennet is introduced may vary somewhat according to other conditions. In the experiment reported in the following pages it will be seen that this temperature varied from eighty-two to eighty-six degrees; eighty-four to eighty-six is usually considered best. The milk should be thoroughly, but gently, stirred for a minute and a half to two minutes after the rennet is added, then quieted down as quickly as possible by passing the dipper gently over the surface, and allowed to remain undisturbed until complete coagulation has taken place. Any agitation of the milk while it is undergoing coagulation causes a loss of fat in the whey. It is best to cover the vat with a canvas or muslin cloth while coagulation is taking place. This prevents the surface of the curd from becoming chilled if the room is cold and also keeps out specks of dirt and foreign matter.

CUTTING THE CURD.—The time at which the curd is in the best condition for cutting is determined by passing the finger along about half an inch under the surface, first splitting the curd with the thumb; if the curd breaks clean before the finger, leaving only moisture in its wake, it is in fit condition for cutting. Beginners are apt to cut before the curd is firm enough; it is something that must necessarily be learned by experience. If the curd is cut too soft it does not retain its form and body in the after-stirring and manipulation and a great deal of fat will be lost in the whey. At this stage the curd is very tender and easily injured, and the amount of fat lost in the whey depends mainly upon the manner in which the curd is handled in the process of cutting and stirring. The old English method was to break the curd gently with the hands; then wire breakers were introduced. The knives as we now have them were invented and first used in America. These knives are superior to any other instrument used for the purpose, for the reason that they cut the curd cleanly and bruise it very little. The point is to divide the curd thoroughly, but to do so in the gentlest manner and with the least possible agitation. The best instrument is the one that will pass through the curd with the greatest ease and the least amount of friction. The knives should always be kept sharp and clean.

The object in cutting is to facilitate the separation of the curd from the whey, and it should be performed in a manner least injurious to the curd and most favorable to the saving of the butter fat. It is best to use the horizontal knife first. The knife should be held in warm water for a moment or two before using, so that it will be of the same temperature as the curd. It should be introduced very carefully, placing it flat on the surface and cutting downward with the lower end until the latter rests on the bottom of the vat; then it should be slowly moved from one end of the vat to the other, turning carefully at the ends in such a manner that the curd will always be cut and never broken. When cutting is completed the knife should be removed as carefully as it was introduced, not lifting directly upward, but slowly raising the lower end and cutting upward. After the first cutting the curd should be allowed to settle until almost entirely covered by the whey before being cut again. The reason for this is evident. The cut surfaces of the curd are very raw and tender and will part with the fat very easily on being crushed or mangled, or even much agitated. If the curd is permitted to remain undisturbed for a few minutes a film or coating will form over the cut surfaces, and there is much less danger of losing fat. When the curd is almost covered with the whey it is cut again, this time crosswise of the vat and with the perpendicular knife. Then, after allowing it to remain undisturbed for a few minutes, the hands are very gently inserted and whatever pieces of curd along the sides and in the corners have escaped cutting are gently raised to the surface and the curd cut again, lengthwise of the vat with the perpendicular knife. The fineness with which the curd is cut depends upon the condition of the milk and the season of the year. The object is to cut just fine enough to expel the moisture sufficiently and no finer. It is evident that the finer the curd is cut the greater the loss of fat in the whey, other things being equal. Usually the cubes of curd should be about the size of raisins. When the cutting is completed the curd should be allowed to settle for a few minutes, but it should be watched and prevented from matting. Then begin to stir very gently, lifting the curd from the bottom of the vat to the surface, and giving it a rotary motion so the pieces of curd will fall apart. This stirring should be continued for five to ten minutes before any heat is applied. The object is to expose all sides of the freshly cut cubes of curd to the action of the whey, so that a film will form over the freshly cut surfaces and thus prevent the escape of fat.

"COOKING" THE CURD.—Cooking is the term quite generally used in referring to the next process in the manufacture of cheese. That the term is a misnomer is evident to any one who is familiar with the process, for in the manufacture of first-class cheddar cheese the temperature is seldom raised above ninety-eight degrees and the curd is not cooked. From the time the curd is cut until it is put in the press it is handled with a view to accomplishing two things. 1. To expel the moisture, retaining only what is necessary to make a palatable cheese and insure perfect curing; 2. To develop a certain amount of acid. However, there appears to be a very close relation between the amount of moisture present and the degree of acid, as under normal conditions the acid is probably the most effective agent in expelling the moisture. The exact relations that heat, acid and moisture bear to each other in the manufacture of cheese are not yet fully understood. We know that the acid is caused by the action of certain germs, as has already been pointed out. We know that many of these acid producing germs grow best and develop acid most readily at a comparatively high temperature, say between eighty-eight and ninety-eight, so that as we raise the temperature more acid is produced. The acid causes the curd to contract, and as the curd contracts the moisture it contains is naturally forced outward. It would seem that heat in itself does not play as prominent a part in expelling moisture from the curd as has heretofore been supposed; that while it is necessary, and one of the main features, in the manufacture of cheddar cheese, yet it mostly accomplishes the result sought indirectly instead of directly. The heat develops the acid; the acid expels the moisture. Some careful experimental work will have to be done in this line before we will be able to clearly understand the exact bearing heat and acid and moisture have upon each other.

In order that the acid may be developed evenly and continuously in all parts of the curd, the temperature should be raised slowly and carefully. Those who do not understand the principle underlying this process and who think that the object is to "cook" the curd as they would poach an egg usually raise the temperature rapidly in order to get the curd "cooked" as quickly as possible. The result is that the rapid raising of the temperature causes a firm coating to form over the exposed surfaces of the cubes of curd which prevents the escape of the moisture held inside. As a consequence they get a cheese that goes off flavor quickly and never cures properly; it contains too much moisture, and we have had some made in this way that parted with some of the extra moisture in the curing room during the first month—"leakers." Such are never satisfactory cheeses to sell, and quite often they sour and become entirely unfit for market. It is necessary that the heat be applied so slowly that the cubes of curd have time to become heated through and through before a tough film is formed on the surface. When the heat has been properly applied, if one of the cubes of curd be broken open when it is in condition to be removed from the whey it will be firm and stiff from one side to the other. On the other hand, when the heat has been applied too rapidly, the inside of the cubes will be soft and milky, a film having been formed on the surface before the moisture was forced out. With normal milk in good condition the heat should be applied in such a manner that the temperature will be raised about one degree in two and one-half to four minutes. It should not be heated faster than this unless the milk is in such condition that it is necessary to hasten the process to avoid too much acid. Some points of interest in regard to heating will be pointed out in the detailed report of the experiment which follows.

While the temperature is being raised it is necessary to stir the curd frequently, to keep the temperature the same in all parts of the vat and to prevent the curd from becoming matted together. It should be stirred, however, no more than is necessary to accomplish these ends. The manner in which the curd should be stirred is one of the most difficult things for the beginner in cheese-making to learn, and thousands of dollars worth of fat are annually lost in the cheese vats of the country because of improper stirring of the curd from the time it is cut until the whey is removed. Bearing in mind the manner in which the fat is retained in the curd it is plain that the more the curd is agitated the greater will be the loss of fat in the whey, other things being equal, and while it is necessary to stir frequently during the heating process to keep the temperature the same throughout the vat and to prevent the cubes of curd from matting together, more stirring than this is not only useless, but means a positive increase in the loss of fat in the whey. There is a knack in knowing how to stir curd in the whey. One maker will secure an even temperature and keep the cubes separate so gently and carefully that the minimum amount of fat will be lost, while another will stir so violently that he will lose more fat in the whey than his wages amount to, if he is handling large quantities of milk. The stirring should be done in the gentlest possible manner. In a small vat it is best to use the hands only. In a large vat it is easier and more convenient to use a large wooden rake for the center of the vat, keeping the corners clear of curd with the hands. Care should be taking to avoid bruising the curd and crushing it against the sides and ends of the vat.

As will be seen by referring to the detailed report of the methods of manufacture of cheese in this experiment, the temperature in the vat was seldom raised above ninety-eight to ninety-nine degrees. This is generally considered the proper temerature to reach in the heating of the curd in the whey. Shortly after this temperature has been reached, when the cubes of curd become so firm that they will not "run together," the curd can be allowed to settle to the bottom of the vat, being stirred up occasionally, until the proper degree of acidity is developed. Before allowing the curd to come in contact with the bottom of the vat for any length of time, however, the water surrounding the vat should be brought to the same temperature as the curd and whey, so that there will be no danger of the curd on the bottom of the vat becoming too warm. Unless the maker is careful in this matter the temperature is likely to run up higher than it should. In regard to the temperature to which the curd should be heated, there is a tendency among practical makers in some localities to stop at a lower temperature than has heretofore been considered best, some stating it as their belief that as satisfactory results are secured when heating is discontinued at ninety as when it is carried on up to ninety-eight. It should be noted in this connection that the investigations of some bacteriologists tend to show that many of the germs found in cheese do not grow well at a temperature above ninety-five, some in fact being retarded in growth at that temperature. However, it remains to be seen whether any of the germs of this nature are essential to the making of first-class cheese. The whole subject is open for careful experimental work, and the temperature to which it is best to heat the curd can only be determined when we have a more thorough knowledge of the forces at work which bring about the desired changes in the curd.

ACIDITY IN THE WHEY.—The curd is allowed to remain in the whey until a certain amount of acidity is developed, the amount depending somewhat on the season, the locality and the condition of the particular curd in hand. The main purpose in developing acidity in the curd while it is still in the whey is to aid in getting rid of the moisture and to save time. Time is saved in this manner because while the whey is still present there is more sugar available for the development of acidity than after the whey has been removed. The whey could be removed as soon as the temperature had been raised to the desired point, and while it was still sweet, and it would be possible to develop all the acidity in the curd; but it would be a slow process, requiring a great deal of time and watchful care, and there would be danger of retaining too much moisture in the curd. But, while the development of a certain amount of acidity in the whey is helpful and advantageous, the greatest care must be exercised so that the acidity can be arrested before it proceeds too far. In the latter case one of two evils is the result: either the natural process must be cut short and the curd hurried into the hoops before it is in the proper mechanical condition for pressing, or the amount of acid will be much greater than it should be at the time of pressing. In the first instance there is usually too much moisture in the cheese, and not only are the body and texture poor but the cheese goes off flavor quickly. In the second case, when too much acid is developed the cheese is likely to be hard and does not cure well, because the presence of too much acid tends to arrest the growth of the germs which cause ripening. That buttery consistency and "nutty" flavor characteristic of first-class cheese is lost, and it is impossible to make a really fine article if the development of acid is carried too far in the whey. It is the belief of many of the best cheesemakers, both in this country and England, that the whey contains elements inimical to the finest flavor, and that the sooner it can be removed the better. It is quite possible that some of the germs which develop undesirable flavors in cheese grow best in the whey, but we are as yet almost entirely in the dark as to the parts different germs play in the production of flavors in cheese.

As to the exact degree of acid that should be given in the whey, as shown by the hot iron test with which all cheesemakers are familiar, it necessarily varies with the season and the locality, and each maker must be governed by his own judgment in accordance with the surroundings. In making spring cheese we usually remove the whey when the curd shows threads an eighth of an inch long on the hot iron; in summer when the threads are about one-fourth of an inch long. In the fall we allow somewhat more acid to develop in the whey, the amount depending upon the market for which the cheese is made. The demand in this state is for a softer cheese than would be best for shipping purposes, and consequently less acid is needed than would be necessary in the latter case.

In warm weather, when the acid develops rapidly, it is a good practice, especially for those who have large vats to handle, to remove one-half or more of the whey before very much acid is developed. This does not arrest acidification, but when there is only a small amount of whey on the curd it can be removed quickly when the proper time comes, and this is important.

Management of the Curd.—After drawing off the bulk of the whey the curd should be well stirred, to give the remainder of the whey an opportunity to escape, and to matted on each side of the vat, keeping an open channel through the center through which the whey can run off as it is pressed out by the settling of the curd. The method of handling the curd at this point must necessarily depend upon its condition. Sometimes, instead of permitting it to mat it is dipped into a curd sink and well stirred, the length of time stirring is continued depending upon the amount of moisture in the curd, and then matted until sufficient acid is developed. At other times, when development of acid is rapid, it is not allowed to mat at all; simply dipped from the vat to the curd-sink, stirred according to the judgment of the maker, salted, stirred and put to press. In this experiment we matted the curd in the vat, although in one or two cases, as will be noticed in the detailed report, we found it necessary to vary the process somewhat because of the unusual development of acidity.

After the curd is matted firmly it should be cut into blocks six or eight inches across, so that it can be turned and piled. At this stage the curd is handled with two objects in view, to get it in the proper mechanical condition and remove the whey as thoroughly as possible, and to develop a certain amount of acid. The blocks of curd should be turned at intervals of ten to fifteen minutes to give the whey an opportunity to flow off easily, and then piled, two deep at first and then three or four deep, unless the temperature of the make room be rather high. Care should be taken to see that the whey is not allowed to stand in pools on the curd at this point. If this is permitted there is danger of too much moisture being retained in the curd, and of sour flavors being developed in the cheese.

It is important that the temperature of the curd be kept at ninety to ninety-six while the curd is in the matted condition. This is necessary, not only for the development of acid, but to secure the proper mechanical condition. If the make-room be cold, so that there is danger of the curd cooling quickly, the latter should be covered with pieces of heavy cloth to prevent the radiation of the heat, and the water surrounding the vat can be kept at ninety-six to one hundred, as seems best. In the latter case, however, the curd should be placed on racks, so that it will not be exposed to the hot sides and bottom of the vat. Another aid in maintaining the temperature is to pile the blocks of curd three or four, or more, deep; and this is also necessary to secure the best mechanical condition. The idea is to keep the curd warm, thus making the conditions favorable for the growth of the germs which produce the acidity. It will not do, however, to simply pile the curd and permit it to remain in this condition, for the reason that most of these acid-producing germs seem to require the presence of air to grow readily; so the blocks of curd should be turned and re-piled every ten to fifteen minutes, for the double purpose of exposing them to the air and to get rid of the whey which collects, as well as to maintain an even temperature in all parts of the curd and thus secure an even and regular development of acidity.

The degree of acid developed while the curd is in the matted condition necessarily varies with the season and the condition of the milk. In the spring we grind the curd when the threads string out from one-half to one inch on the hot iron, usually about three-fourths of an inch. In making summer and fall cheese we give one to one and two-thirds inches, depending upon the condition of the milk and the market for which we are making the cheese. Experience and judgment are necessary in this matter, as in everything connected with cheesemaking. As for mechanical condition, when the curd is in the best condition for grinding it is flaky, and when torn apart splits instead of breaks. At this stage it has a peculiar odor, which has been likened to the breath of a healthy cow. The curd never attains the proper mechanical condition if the temperature be too low while it is in the matted condition.

Grinding the Curd.—The kind of mill best adapted to leave the curd in the most satisfactory condition after grinding and to cause the least loss of fat, we believe, has not been determined by careful experiments. Successful makers differ in opinions in this matter. In this experiment a knife mill was used, the curd being cut in strips instead of torn apart, not because we had sufficient grounds for believing it better than some other mills made, but because it was the only one we had at hand. We have lately secured what is believed to be the best peg mill made, and shall test it in comparison with mills of other kinds.

The temperature at which the curd should be put through the mill is something that we think is not entirely settled.

Among the best makers there is the belief that the temperature should be reduced below ninety before grinding, and we think there may be good grounds for this belief. It is difficult to lay down any rule to govern this particnlar part of the process; in this as in almost everything else connected with cheese-making, the maker must modify his practice to meet the requirements of the particular curd in hand. Until we get some strong indications by experimentation as to the best temperature at which the curd should be ground, we shall be governed more by the condition of the curd mechanically and the amount of acid present; although as stated above, we think it desirable to reduce the temperature to near ninety, and perhaps below, if it can be done without interfering with the other conditions. In other words, from the present state of our knowledge on this point we regard the matter of temperature as secondary.

SALTING THE CURD.—The length of time that should elapse between grinding the curd and adding the salt must depend to a great extent upon the condition of the curd in hand. Sometimes the curd will be ready for salting in five to ten minutes after being ground, while at other times salting is best deferred for twenty minutes to half an hour, or more. After being ground the curd should be well stirred and thoroughly exposed to the air, thus giving the moisture an opportunity to evaporate, and the length of time it should be stirred before the salt is added naturally depends somewhat upon the amount of moisture in the curd and the amount it is desirable to have in the cheese. Normal curd is usually in fit condition to salt when it has been stirred fifteen to twenty minutes after having been ground. It will be noticed that the character of the curd changes somewhat during this period. The aroma of new made butter becomes pronounced as the curd is more exposed to the air, the odor no doubt being produced by the action of the germs in the curd, the conditions for their growth being most favorable at this point. As stirring is continued the mechanical condition of the curd changes, and when ready for salting it has a soft, silky feel, and when squeezed firmly in the hand a mixture of whey and butter fat oozes out between the fingers. If there be a certain temperature at which it is best to add the salt we do not yet know what it is. As will be seen by reference to the details of the manufacture of the cheese in this experiment we added the salt when the curd was at a temperature of about eighty. Whether this temperature should be raised or lowered, as is more likely, is something that can only be determined by careful experimentation.

The amount of salt to use varies with the season, the condition of the curd as regards moisture and the length of time within which it is desired to market the cheese. The action of salt in expelling moisture from either butter or cheese is well understood, and also its preservative qualities. It retards the growth and reproduction of the germs which cause ripening and decay. Consequently, when quick curing cheese is desired, less salt is used than when the intention is to keep the cheese in the curing room for several months. In the spring and early summer less salt is used than in the fall and winter. In general it may be said that during the spring, when it is desired to place the cheese on the market as quickly as possible, one and one-half to one and two-thirds pounds of salt to the thousand pounds of milk should be used, while in the latter part of the season this amount can be increased until two and one-half to three pounds, or more, can be used to the thousand pounds of milk. After the salt is added the curd must be well stirred to secure its even distribution. The length of time that should elapse from the addition of the salt until the curd is placed in the hoops naturally varies with the conditions. Usually, however, the curd is in fit condition for hooping within fifteen to twenty minutes after the salt has been added. Immediately after the salt is added it will be observed that the curd has a harsh, gritty feel on the surface, caused probably by the action of the salt on the casein; when this harsh feeling has entirely disappeared and the curd has become soft and slippery to the touch, it is ready for the hoops. In case there are disagreeable odors present in the curd it is improved by stirring fifteen to thirty minutes longer than usual.

PRESSING THE CURD.—The main object in pressing is to secure a firm, compact cheese, and to remove the extra moisture. The temperature at which it is best to put the curd to press is another of those points that has not been entirely determined as yet. In this connection there are two things to be kept in mind, the amount of fat lost in the press drip and the flavor of the cheese. As to the amount of fat lost in the drip, by reference to the detailed report of the manner in which the cheese in this experiment were made, it will be seen that it is really insignificant. While in some cases the drip shows a high per cent of fat there is so little of it usually that the actual loss of fat is very small, indeed. As for the bearing the temperature at which the curd is put to press has upon the flavor of the cheese some of those who are entitled to be ranked as authorities hold that it affects it materially, and that in order to secure the best flavor the curd should go in the press at a temperature of seventy-eight to eighty. This is another matter that must be determined by careful experimentation.

The hoops should be of nearly the same temperature as the curd at the time the latter is placed in them; if they are cold there is danger of the curd in contact with them becoming chilled, and failing to form a firm, close rind. Cold hoops and cold press-rooms have been fruitful sources of trouble to makers, and cracked rinds can frequently be traced to this cause. The pressure should be applied with a view to secure a close knitting together of the curd, hence it must be done slowly and gradually. If pressure is applied too violently the loss of fat in the whey will be much greater than it should, and what is worse, the curd will be crushed out of shape, making it pasty and destroying the body of the cheese. As soon as the whey starts through the openings in the hoop, pressure should be discontinued for ten minutes, or more, then increased slightly and again stopped for a few minutes, and so on until the curd is under almost full pressure. In this condition the curd should remain for ten to fifteen minutes, when the hoops should be taken from the press, the cheese turned and the bandages neatly pulled up and folded over the ends so that they will fit the cheeses smoothly. The cap cloths should be rinsed in warm water and a little of the latter sprinkled on the ends of the cheese, when the latter should be returned to the hoops and replaced in the press under strong pressure. The pressure should be increased as much as possible the last thing in the evening and the first thing on returning to the room in the morning. Ordinarily eighteen to twenty-four hours is a sufficient length of time for cheese to remain in the press, although in certain cases, as when the curd has not knit well together, or has been pressed too much on one side or the other, it is better to press sometime longer.

On taking the cheese from the press the cap cloths are removed—they should peel off neatly without any abrasion of the rind—and after the cheese has been exposed to the air in the curing room for an hour or so, in order that the surface moisture may evaporate, the ends are greased with melted butter or grease made for the purpose. If butter is used it should be put on hot so that a good rind will be formed, and the ends rubbed for a few minutes. Of late we have been using a prepared grease that is giving satisfactory results. On the side of each cheese should be plainly marked the date on which it was made. The cheese should be turned and rubbed on the ends every day and the shelves kept clean and dry. The idea in turning is to secure an even distribution and evaporation of the moisture in the cheese, and to expose both ends to the air. If turning is neglected, the end next to the shelf, being filled with moisture which has gradually settled to it, will decompose. There is sometimes trouble caused by the ends of the cheese becoming colored, usually a reddish color. This can frequently be traced to the boards of which the shelves are made. If unseasoned pine boards are used they will very often color the cheese. The remedy is to use only well seasoned lumber in the curing room, particularly avoiding knotty and pitchy boards. If the shelves are not kept clean the ends of the cheese will become colored more or less, and the same thing frequently results if the air in the room is too heavily laden with moisture, the coloring in the latter case being probably due to the action of certain germs.

RIPENING.—One of the most desirable characteristics of the old cheddar cheese was that it was usually well ripened before being placed on the market. The process of ripening was carried on for several months, and when placed on the market the cheese was buttery, of fine flavor and digestible. In this country there is a good demand for young cheese, and this, coupled with the fact that good curing rooms and considerable capital are required to hold the product of the factory for three to five months, the time required for thorough ripening, has brought about the practice of selling cheese within a few weeks after they are made. Among critical customers, however, first-class, well ripened cheese command a premium of several cents a pound, and the demand for cheese of this kind will grow as the consumers become educated to an understanding of its value. One of the main objects of this experiment was to study the ripening of cheese, and especially the ripening of cheese made from milk containing different amounts of fat, with a view to determining as far as possible whether it is profitable to ripen cheese thoroughly before placing it upon the market. The report of this part of the work is necessarily deferred for a few months.

DETAILS OF THE EXPERIMENT.

The milk used in making the cheese was that brought into the factory by the patrons living in the surrounding country. During the time these cheeses were made milk was brought in only three times per week, so that usually it was older than that ordinarily made into cheese later in the season, although we attempted to avoid ripe milk and secured the best of the first loads brought in. Except in two or three cases when it was ripe the milk was in good condition when placed in the vat. The per cent of fat in the milk was governed by skimming and by the addition of cream. When the milk contained the amount of fat desired, as determined by the Babcock test, it was thoroughly stirred and a pint sample taken and sent to the chemical laboratory. Samples of the whey were taken at three different times during the process of manufacture. As spoken of in the following tables the first whey was the main portion of the whey; the second whey was that which drained from the curd from the time it was piled until it was put to press; the term, "press drip," explains itself. As will be noticed there were usually only a few pounds each of the second whey and press drip, and while in some cases the analysis shows a high per cent of fat in these samples the actual amount of fat lost was very small. The first whey was dipped into another vat and thoroughly stirred before the sample was taken, and care was taken to get representative samples in every case. The analyses given in the following tables are those reported by the station chemist. Analyses of the different samples were also made by the Babcock method, and the results of these analyses of the first whey are given in a line below the report on each cheese. The cheese was sampled and the sample sent to the chemical laboratory the day it was removed from the press, and it is the report of the analyses of these samples that is given in the following tables.

Table No. I gives the report of the process of manufacture in detail. The table explains itself. The "degree of acid on iron" is expressed in terms of inches, meaning, of course, the length to which fine threads were drawn out when a piece of the curd, having been firmly squeezed in the hand to press out the whey, was applied to the surface of a hot iron.

Table No. I.—Giving Detailed Report of Process of Manufacture.

	Cheese No. 1	Cheese No. 2	Cheese No. 3	Cheese No. 4	Cheese No. 5	Cheese No. 6	Cheese No. 7	Cheese No. 8
Pounds of Milk	442	430	445	423	410	441	415	448
Per cent Fat	1.75	2.49	3.07	3.58	4.05	4.07	4.20	4.61
Began Heating at	11:15	11:10	11:45	11:35	11:20	12:06	12:00	11:25
Degrees of Temp. Reached	84at 11:30	84at 11:30	84at 12:10	84at 12:10	86at 11:32	84at 12:3	86at 12:35	86at 11:45
Condition of Milk	Good	Good	Good	Good	Good	Good	Good	Good
Amount of Color	½ oz	½ oz	½ oz	½ oz	½ oz	½ oz	½ oz	½ oz
Added Rennet at	11:35	11:42	12:16	12:12	11:39	12:50	12:28	12:05
Amount of Rennet	2¼ oz	2¼ oz	2¼ oz	2½ oz	2 oz	2½ oz	2¼ oz	2 oz
Began to Coagulate	11:44	11:50	12:24	11:21	11:51	12:58	12:3	12:12
Cut Curd at	12:8	12:20	12:47	12:51	12:15	1:15	1:10	12:24
Began to stir at	12:44	1:05	1:20	1:25	12:50	1:35	2:25	12:40
Heat Applied at	1:10	1:15	1:30	1:35	1:07	1:43	2:33	12:58
Stopped Heating at	1:40	2:00	2:1	2:20	1:45	2:20	3:0	1:40
Temperature, Degrees	98	98	98	98	100	100	98	100
Whey Drawn at	3:55	2:15	3:27	4:30	5:20	3:23	3:10	2:45
Degree of Acid on Iron	⅛ in	⅛ in	⅛ in	⅛ in	¼ in	⅛ in	⅛ in	⅛ in
Pounds 1st Whey	393	370	388	364	386	380	381	384
Per cent Fat	.15	.17	.17	.13	.31	.28	.28	.3[illegible]
Curd Piled at	4:10	2:53	3:35	4:40	5:30	3:35	3:2[illegible]	3:00
Curd Milled at	4:55	3:35	4:45	4:20	6:10	4:20	4:30	4:10
Temp. Curd, Degrees	[illegible]3	94	97	96	96	95	97	96
Degree of Acid on Iron	½ in	¾ in	½ in	½ in	1 in	¾ in	½ in	1 in
Added Salt at	5:05	5:50	6:05	4:35	6:25	4:35	4:45	4:25
Pounds Salt	¾	1	1¼	1¼	1¼	1¼	1¼	1¼
Temperature Curd	80	82	79	80	82	8[illegible]	8	82
Pounds 2d Whey	10	7.5	9	12	6	13	7	5.5
Per cent Fat	.07	.04	.08	.00	24	.25	.17	.82
Curd Hooped at	5:20	4:05	5:20	5:50	6:40	4:45	5:00	4:55
Temp. Hooped, Degrees	78	79	77	77	77	78	77	77
Pounds Press Drip	2.5	4.5	4	5	4	3	3½	1½
Per cent Fat	.24	.61	.41	1 06	1.07	.57	.45	1.69
Number Hours in Press	19	18½	16¾	24	20	17	40	24
Weight Green Cheese	35	38 5	41	42	43.5	45	4[illegible].5	51 5

	Cheese No. 9	Cheese No. 10	Cheese No. 11	Cheese No. 12	Cheese No. 13	Cheese No. 14	Cheese No. 15
Pounds of Milk	3[illegible]7	4[illegible]3	417	4[illegible]1	390	42[illegible]	379
Per cent Fat	4.98	5.10	5.45	6.18	6.81	6.83	8.40
Began Heating at	11:30	11:20	11:30	11:27	11:45	11:55	12:00
Degrees of Temp. Reached	86at 11:40	86at 11 45	86at 11:48	84at 11:47	86at 12:0	86at 12:15	85at 12:10
Condition of Milk	Very ripe	Good	Good	Good	Good	Good	Ripe
Amount of Color	⅛ oz	⅛ oz	⅛ oz	½ oz	⅛ oz	⅛ oz	⅛ oz
Added Rennet at	11:45	11:55	12:03	11:54	12:04	12:18	11:40
Amount of Rennet	2 oz	2 oz	2 oz	2¼ oz	2 oz	2 oz	1¼ oz
Began to Coagulate	11:50	12:05	12:15	12:01	12:4	12:28	11:47
Cut Curd at	12:00	12:50	12:48	12:31	12:40	12:5[illegible]	12:17
Began to stir at	12:06	1:0	1:30	12:39	12:58	[illegible]:20	12:45
Heat Applied at	12:10	1:40	1:40	12:45	1:08	1:30	12:55
Stopped Heating at	12:25	2:2	2:25	1:15	1:50	2:10	1:24
Temperature, Degrees	102	100	100	98	9[illegible]	100	101
Whey Drawn at	12:35	4:05	4:45	2:12	2:05	3:05	1:45
Degree of Acid on Iron	3-16 in	¼ in	⅛ in	¼ in	⅛ in	⅛ in	⅛ in
Pounds 1st Whey	287	341	357	333	308	356	3[illegible]0
Per cent Fat	.63	.54	.45	.43	.66	[illegible]8	.65
Curd Piled at	12:55	4:20	5:00	2:40	2:25	3:20	2:10
Curd Milled at	1:10	4:45	5:30	3:[illegible]3	4:10	4:15	2:20
Temp. Curd, Degrees	94	92	97	97	97	95	84
Degree of Acid on Iron	¾ in	¾ in	¾ in	¾ in	1 in	¾ in	¾ in
Added Salt at	1:15	5:05	5:45	3:5	4:30	4:30	2:25
Pounds Salt	1¼	1¼	1¼	1¼	1¼	1¼	2
Temperature Curd	82	75	85	77	84	78	77
Pounds 2d Whey	22	26.5	8	80	25	6	3
Per cent Fat	.82	2 27	.27	2.17	2.26	.71	4 48
Curd Hooped at	1:40	5:25	6:10	3:27	4:55	5:10	2:55
Temp. Hooped, Degrees	80	7	80	72	82	70	75
Pounds Press Drip	6	3	2	5	5	2	3
Per cent Fat	1.31	.74	.85	1.14	17.81	1.04	7 49
Number Hours in Press	19	18	24	17	20	16	44
Weight Green Cheese	41 75	52.5	50	58	51	59	63 00

By referring to the preceding table we find the following:

The average temperature of the milk when the rennet was added was 85 degrees.

The average length of time from the introduction of the rennet until the coagulation began was 8.6 minutes.

The average length of time from the introduction of the rennet until the curd was cut was thirty-four minutes.

The average length of time that elapsed from the time cutting of the curd was begun until stirring was begun was twenty seven minutes.

The average length of time that elapsed from the time the cutting of the curd was begun until heat was applied was forty-one minutes.

The average length of time consumed in raising the temperature to the required point was thirty-seven minutes, or at the rate of one degree in a little more than two and one-half minutes.

The average temperature to which the curd was "cooked" was 99 degrees.

The average per cent of fat lost in the first whey, as determined by gravimetric analysis, was 0.37. The average per cent lost with milk containing less than four and one-half per cent fat was but 0.21.

The average per cent of fat lost in the first whey, as shown by the Babcock test, was 0.26. The average per cent lost with milk containing less than four and one-half per cent fat was but 0.13.

The average length of time that elapsed from the milling of the curd to the addition of the salt was fourteen minutes.

The average number of hours the cheese were allowed to remain in press was twenty-two and one-half.

Especial attention is called to the length of time that elapsed between the commencement of cutting and the time stirring was begun, and between the commencement of cutting and the time heat was applied. We attribute the small loss of fat in the whey to carefulness in handling the curd from the time cutting was begun until heating was completed. It is the custom of a great many makers to complete the cutting of the curd in five or ten minutes and immediately apply heat and begin to stir. That this causes excessive losses of fat in the whey there can be no doubt. With one or two exceptions, when the milk was ripe and working fast, we allowed the curd to settle until it was almost entirely covered with the whey after each cutting before again introducing the knife, and stirring was not begun until it was necessary in order to prevent the curd from matting on the bottom. The stirring was always done in the gentlest possible manner, and the curd was not agitated more than was absolutely necessary to distribute the heat evenly and keep it from matting together. We believe that the more time that can be taken in cutting the curd, and the longer stirring can be deferred, the less will be the loss of fat in the whey, other things being equal.

The following pages contain tables for each of the fifteen cheeses made, showing the pounds and percentage composition of the milk from which the cheese was made, first whey, second whey, press drip and green cheese, and the total number of pounds of fat and casein and albumen in each. These figures represent the result of the analyses made in the chemical laboratory. The cheese are numbered according to the amount of fat contained in the milk from which they were made, Number 1 being the cheese made from the milk containing the lowest per cent of fat, and Number 15 being the cheese made from the milk containing the highest per cent of fat. It will be noticed that the percentages of ash and total solids in the press drip are very high. This is accounted for by the fact that the drip contained a great deal of salt which appears as ash in the analysis. For the same reason the per cent of ash in the green cheese is much higher than it would be otherwise.

Cheese No. 1.

Table showing the pounds and percentage composition of the milk, first and second wheys. press drip and green cheese, and the total number of pounds of fat and casein and albumen in each.

	Pounds.	Fat.	Casein and albumen.	Sugar.	Acid (lactic).	Ash.	Total solids.	Moisture.	Pounds fat.	Pounds casein and albumen.
Milk	442	1.75	3.72	4.96	.2	.67	10.98	89.02	7.735	16.442
First whey.	393	.15	.8	5.20	.27	.54	6.90	93.10	.589	3.144
Second whey	10	.07	.76	4.90	.30	.64	6.86	93.14	.007	.076
Press drip...	2.5	.24	.80	3.10	1.05	7.12	12.70	87.30	.006	.020
Green cheese	35	21.77	29.41	00	2.16	4.61	57.95	41.65	7.619	10.293

The amount of fat lost in the first whey, as shown by the Babcock test, was 0.05 per cent.

Total amount fat lost during process of manufacture was .602 pounds, or a little more than 7.7 per cent of the original amount of fat in the milk.

Total amount of casein and albumen lost during process of manufacture was 3.24 pounds, or about 19 per cent of the original amount of casein and albumen in the milk.

Cheese No. 2.

Table showing the pounds and percentage composition of the milk. first and second wheys. press drip and green cheese, and the total number of pounds of fat and casein and albumen in each.

	Pounds.	Fat..	Casein and albumen.	Sugar.	Acid (lactic).	Ash.	Total solids.	Moisture	Pounds fat.	Pounds casein and albumen.
Milk	430	2.49	2.88	5.16	.21	.71	11.67	88.33	10.707	12.384
First whey..	379	.17	.78	5.23	.22	.49	6.93	93.07	.644	2.956
Second whey	7.5	.04	.94	5.10	.32	.68	6.93	93.07	.003	.070
Press drip...	4½	.61	.96	2.40	.53	7.45	13.32	86.68	.027	.043
Green cheese	38½	26.35	25.09	00	2.01	4.25	57.70	39.85	10.144	9.659

The amount of fat lost in the first whey, as shown by the Babcock test, was 0.05 per cent.

The total amount of fat lost during the process of manufacture was 0.674 pounds, or a little less than 6.3 per cent of the original amount of fat in the milk.

The total amount of casein and albumen lost during the process of manufacture was 3.069 pounds, or about 24 per cent of the original amount of casein and albumen in the milk.

Cheese No. 3.

Table showing the pounds and percentage composition of the milk, first and second wheys, press drip and green cheese, and the total number of pounds of fat and casein and albumen in each.

	Pounds.	Fat.	Casein and albumen.	Sugar.	Acid (lactic).	Ash.	Total solids.	Moisture.	Pounds fat.	Pounds casein and albumen.
Milk	445.	3.07	3.05	5.23	.19	.7	11.97	88.03	13.661	13.572
First whey ..	388.	.17	.78	5.13	.26	.46	6.83	93.17	.659	3.026
Second whey	9.	.08	.82	4.93	.26	.55	6.79	93.21	.007	.073
Press drip...	4.	.41	1.12	3.30	.43	8.20	14.00	86.00	.016	.044
Green cheese	41.	30.55	25.25	00	.83	4.60	61.23	37.67	12.525	10.352

The amount of fat lost in the first whey, as shown by the Babcock test, was 0.1 per cent.

The total amount of fat lost during the process of manufacture was 0.682 pounds, or a little more than 4.9 per cent of the original amount of fat in the milk.

The total amount of casein and albumen lost during the process of manufacture was 3.143 pounds, or about 23 per cent of the original amount of casein and albumen in the milk.

Cheese No. 4.

Table showing the pounds and percentage composition of the milk, first and second wheys, press drip and green cheese, and the total number of pounds of fat and casein and albumen in each.

	Pounds.	Fat.	Casein and albumen.	Sugar.	Acid (lactic).	Ash.	Total solids.	Moisture.	Pounds fat.	Pounds casein and albumen.
Milk	423.	3.58	2.70	5.23	.18	.69	12.12	87.88	15.143	11.421
First whey ..	364.	.13	.67	4.90	.20	.49	6.89	93.11	.473	2.438
Second whey	12.	00	.69	4.60	.28	.57	6.10	93.90	000	.082
Press drip...	5.	1.06	1.21	2.80	.38	7.86	14.29	85.71	.053	.060
Green cheese	42.	32.02	20.75	00	1.55	3.73	58.05	39.58	13.448	8.715

The amount of fat lost in the first whey, as shown by the Babcock test, was 0.15 per cent.

The total amount of fat lost during the process of manufacture was 0.526 pounds, or a little more than 3.4 per cent of the original amount of fat in the milk.

The total amount of casein and albumen lost during the process of manufacture was 2.58 pounds, or about 22 per cent of the original amount of casein and albumen in the milk.

Cheese No. 5.

Table showing the pounds and percentage composition of the milk, first and second wheys, press drip and green cheese, and the total number of pounds of fat and casein and albumen in each.

	Pounds.	Fat.	Casein and albumen.	Sugar.	Acid (lactic).	Ash.	Total solids.	Moisture.	Pounds fat.	Pounds casein and albumen.
Milk	440	4.05	3.00	5.10	.20	.69	13.04	86.96	17.820	13.200
First whey ..	386.	.34	.84	4.86	.42	.52	6.80	93.20	1.312	3.242
Second whey	6.	.24	.54	2.63	.27	.39	3.96	96.04	.014	.032
Press drip...	4.	1.07	1.15	2.70	.55	10.45	16.39	83.61	.042	.046
Green cheese	43.5	36.40	22.77	00	1.41	4.17	64.75	33.90	15.834	9.904

The amount of fat lost in the first whey, as shown by the Babcock test, was 0.15 per cent.

The total amount of fat lost during the process of manufacture was 1.368 pounds, or a little more than 7.6 per cent of the original amount of fat in the milk.

The total amount of casein and albumen lost during the process of manufacture was 3.32 pounds, or about 25 per cent of the original amount of casein and albumen in the milk.

Cheese No. 6.

Table showing the pounds and percentage composition of the milk, first and second wheys, press drip and green cheese, and the total number of pounds of fat and casein and albumen in each.

	Pounds.	Fat.	Casein and albumen.	Sugar.	Acid (lactic).	Ash.	Total solids.	Moisture.	Pounds fat.	Pounds casein and albumen.
Milk	441	4.07	3.03	5.03	.19	.75	12.74	87.26	17.948	13.362
First whey ..	380	.28	.76	5.13	.17	.48	6.85	93.15	1.064	2.888
Second whey	13.	.25	.66	3.40	.18	.46	4.98	95.02	.032	.085
Press drip...	3.	.57	.85	2.73	.32	7.47	13.67	86.33	.017	.025
Green cheese	45.	35.13	20.96	00	1.55	3.54	61.18	36.44	15.808	9.432

The amount of fat lost in the first whey, as shown by the Babcock test, was 0.15 per cent.

The total amount of fat lost during the process of manufacture was 1.113 pounds, or about 6 2 per cent of the original amount of fat in the milk.

Total amount of casein and albumen lost during process of manufacture was 2.998 pounds, or about 22 per cent of the original amount of casein and albumen in the milk.

CHEESE No. 7.

Table showing the pounds and percentage composition of the milk, first and second wheys, press drip and green cheese, and the total number of pounds of fat and casein and albumen in each.

	Pounds.	Fat.	Casein and albumen.	Sugar.	Acid (lactic).	Ash.	Total solids.	Moisture.	Pounds fat.	Pounds casein and albumen.
Milk........	445.	4.20	3.03	4.63	.65	.74	12.82	87.18	18.690	13.483
First whey .	384.	.26	.73	4.73	.39	.47	6.80	93.20	.998	2.703
Second whey	7.	.17	.97	4.50	.41	.65	6.85	93.15	.011	.067
Press drip...	3.5	.45	.89	3.40	.45	9.30	15.07	84.93	.157	.031
Green cheese	48.5	36.75	19.89	00	.92	4.10	61.66	36.86	17.823	9.646

The amount of fat lost in the first whey, as shown by the Babcock test, was 0.25 per cent.

The total amount of fat lost during the process of manufacture was 1.166 pounds, or about 6.2 per cent of the original amount of fat in the milk.

Total amount of casein and albumen lost during process of manufacture was 2.801 pounds, or about 20 per cent of the original amount of casein and albumen in the milk.

CHEESE No. 8.

Table showing the pounds and percentage composition of the milk, first and second wheys, press drip and green cheese, and the number of pounds of fat and casein and albumen in each.

	Pounds.	Fat.	Casein and albumen.	Sugar.	Acid (lactic).	Ash.	Total solids.	Moisture.	Pounds fat.	Pounds casein and albumen.
Milk.... ...	443	4.61	2.94	5.13	.23	.68	13.29	86.71	20.422	12.024
First whey..	384	.38	.74	4.80	.37	.50	6.95	93.05	1.459	2.841
Second whey	5.5	.82	.89	4.76	.36	.60	7.33	92.67	.045	.048
Press drip...	1½	1.69	.83	3.60	.51	8.48	15.28	84.72	.025	.012
Green cheese	51½	38.58	19.87	00	2.68	3.74	64.87	35.48	19.868	10.233

The amount of fat lost in the first whey, as shown by the Babcock test, was 0.15 per cent.

The total amount of fat lost during the process of manufacture was 1.529 pounds, or about 7.4 per cent of the original amount of fat in the milk.

Total amount of casein and albumen lost during process of manufacture was 2.901 pounds, or about 24 per cent of the original amount of casein and albumen in the milk.

CHEESE NO. 9.

Table showing the pounds and percentage composition of the milk, first and second wheys, press drip and green cheese, and the total number of pounds of fat and casein and albumen in each.

	Pounds.	Fat.	Casein and albumen.	Sugar.	Acid (lactic).	Ash.	Total solids.	Moisture.	Pounds fat.	Pounds casein and albumen.
Milk........	357	4.98	2.75	5.16	.24	.65	13.82	86.18	17.778	9.817
First whey..	287	.63	.74	5.00	.25	.52	6.98	93.02	1.808	2.123
Second whey	23	.82	.84	5.00	.24	.66	7.50	92.50	.180	.184
Press drip...	6	1.31	.92	2.80	.32	7.73	14.47	85.53	.078	.055
Green cheese	41.75	40.10	17.14	00	1.33	3.53	62.10	35.84	16.741	7.155

The amount of fat lost in the first whey, as shown by the Babcock test, was 0.30 per cent.

The total amount of fat lost during process of manufacture was 2.066 pounds, or about 11.6 per cent of the original amount of fat in the milk.

Total amount of casein and albumen lost during the process of manufacture was 2.362 pounds, or about 24 per cent of the original amount of casein and albumen in the milk.

CHEESE NO. 10.

Table showing the pounds and percentage composition of the milk, first and second wheys, press drip and green cheese, and the number of pounds of fat and casein and albumen in each.

	Pounds.	Fat.	Casein and albumen.	Sugar.	Acid (lactic).	Ash.	Total solids.	Moisture.	Pounds fat.	Pounds casein and albumen.
Milk........	413	5.10	2.89	5.10	.18	.71	14.11	85.89	21.063	11.935
First whey..	341	.54	.80	5.17	....	.67	7.15	92.85	1.841	2.728
Second whey	26.5	2.27	.88	3.60	.52	.80	8.89	91.11	.601	.233
Press drip...	3	.74	.80	2.40	.40	8.50	13.26	86.74	.022	.024
Green cheese	52.5	46.80	16.63	.4(?)	.92	3.93	68.68	30.25	24.570	8.730

The amount of fat lost in the first whey, according to the Babcock test, was 0.40 per cent.

The total amount of fat lost during the process of manufacture was 2.464 pounds, or about 11.6 per cent of the original amount of fat in the milk.

Total amount casein and albumen lost during process of manufacture was 2.985 pounds, or about 25 per cent of the original amount of casein and albumen contained in the milk.

CHEESE NO. 11.

Table showing pounds and percentage composition of the milk, first and second wheys, press drip and green cheese, and the number of pounds of fat and casein and albumen in each.

	Pounds.	Fat.	Casein and albumen.	Sugar.	Acid (lactic).	Ash.	Total solids.	Moisture.	Pounds fat.	Pounds casein and albumen.
Milk	417	5.45	2.74	....	....	.67	13.91	86.09	22.726	11.425
First whey..	357	.45	.83	5.10	.20	.51	6.90	93.10	1.606	2.963
Second whey	8	.27	.83	4.73	.32	.60	7.25	92.75	.021	.066
Press drip...	2	.85	.88	2.40	.40	7.55	13.69	86.31	.017	.017
Green cheese	50	41.57	17.89	00	1.23	3.68	64.37	34.98	20.785	8.945

The amount of fat lost in the first whey, as shown by the Babcock test, was 0.30 per cent.

The total amount of fat lost during the process of manufacture was 1.644 pounds, or about 7.2 per cent of the original amount of fat in the milk.

Total amount casein and albumen lost during process of manufacture was 3.046 pounds, or about 26 per cent of the original amount of casein and albumen in the milk.

CHEESE NO. 12.

Table showing the pounds and percentage composition of the milk, first and second wheys, press drip and green cheese, and the number of pounds of fat and casein and albumen in each.

	Pounds.	Fat.	Casein and albumen.	Sugar.	Acid (lactic).	Ash.	Total solids.	Moisture.	Pounds fat.	Pounds casein and albumen.
Milk	431	6.18	2.99	5.20	.18	.68	14.93	85.07	26.635	12.886
First whey..	338	.43	.88	5.13	.13	.53	7.06	92.94	1.453	2.974
Second whey	30	2.17	.92	4.93	.22	.56	8.75	91.25	.651	.276
Press drip...	5	1. 4	.91	3.18	.31	10.02	16.10	83.90	.057	.045
Green cheese	58	40.98	16.02	00	1.01	4.25	62.26	35.94	23.768	9.291

The amount of fat lost in the first whey, as shown by the Babcock test, was 0.40 per cent.

The total amount of fat lost during the process of manufacture was 2.161 pounds, or about 8.1 per cent of the original amount of fat in the milk.

Total amount of casein and albumen lost during process of manufacture was 3.295 pounds, or about 25 per cent of the original amount of casein and albumen in the milk.

Cheese No. 13.

Table showing the pounds and percentage composition of the milk, first and second wheys, press drip and green cheese, and the number of pounds of fat and casein and albumen in each.

	Pounds.	Fat.	Casein and albumen.	Sugar.	Acid (lactic).	Ash.	Total solids.	Moisture.	Pounds fat.	Pounds casein and albumen.
Milk	390	6.81	2.84	5.13	.18	.67	15.60	84.40	26.559	11.076
First whey	308	.66	.80	5.20	.20	.49	7.26	92.74	2.032	2.464
Second whey	25	2.26	.89	4.72	.21	.80	9.11	90.89	.565	.222
Press drip	5	17.81	.77	1.19	.36	5.85	25.48	74.01	.890	.038
Green cheese	51	41.60	17.84	.15(?)	1.60	3.32	64.51	34.26	21.216	9.098

The amount of fat lost in the first whey, as shown by the Babcock test, was 0.60 per cent.

The total amount of fat lost during the process of manufacture was 3.577 pounds, or about 13.4 per cent of the original amount of fat in the milk.

Total amount of casein and albumen lost during process of manufacture was 2.724 pounds, or about 24 per cent of the original amount of casein and albumen in the milk.

Cheese No. 14.

Table showing the pounds and percentage composition of the milk, first and second wheys, press drip and green cheese, and the number of pounds of fat and casein and albumen in each.

	Pounds.	Fat.	Casein and albumen.	Sugar.	Acid (lactic).	Ash.	Total solids.	Moisture.	Pounds fat.	Pounds casein and albumen.
Milk	423	6.83	2.94	5.26	.16	.71	15.15	84.85	28.890	12.436
First whey	356	.33	.77	5.16	.13	.52	7.21	92.72	1.174	2.741
Second whey	6	.71	.19	4.10	.22	.61	6.30	93.70	.042	.011
Press drip	2	1.04	.83	....	....	1.74	8.71	91.29	.020	.016
Green cheese	59	41.75	17.02	.3(?)	1.02	3.14	63.23	35.95	24.632	10.041

The amount of fat lost in the first whey, as shown by the Babcock test, was 0.30 per cent.

The total amount of fat lost during the process of manufacture was 1.236 pounds, or about 4.2 per cent of the original amount of fat in the milk.

Total amount of casein and albumen lost during the process of manufacture was 2.768 pounds, or about 22 per cent of the original amount of casein and albumen in the milk.

Cheese No. 15.

Table showing the pounds and percentage composition of the milk, first and second wheys, press drip and green cheese, and the number of pounds of fat and casein and albumen in each.

	Pounds.	Fat.	Casein and albumen.	Sugar.	Acid (lactic).	Ash.	Total solids.	Moisture.	Pounds fat.	Pounds casein and albumen.
Milk	379	8.40	3.00	5.10	....	.70	16.84	83.16	31.836	11.370
First whey..	310	.65	.85	4.87	.20	.62	7.08	92.92	2.015	2.645
Second whey	3	4.93	1.24	3.67	.24	3.93	14.21	85.79	.147	.037
Press drip...	3	7.49	1.37	3.30	.04	13.68	26.18	73.82	.224	.041
Green cheese	63	43.90	14.11	.3(?)	1.24	2.55	62.10	37.70	27.657	8.889

The amount of fat lost in the first whey, as shown by the Babcock test, was 0.6 per cent.

The total amount of fat lost during the process of manufacture was 2.386 pounds, or about 7.4 per cent of the original amount of fat in the milk.

Total amount of casein and albumen lost during the process of manufacture was 2.713 pounds, or about 23 per cent of the original amount of casein and albumen in the milk.

The cheeses were all made in the same manner as nearly as possible and under the same system, different steps in the process of manufacture, however, being varied somewhat as seemed best to meet the requirements of the particular curd in hand. We found it difficult to do the best work in making cheese from milk to which a very large amount of cream was added, in order to bring the per cent of fat up to the required point. Such milk was usually riper, for two reasons; first because it was necessary to hold the milk for some little time, frequently an hour or more, before enough milk was brought into the factory to start the separators, so that cream could be obtained; and second, because of the added cream, which was riper than the normal milk. For this reason the process of manufacture was necessarily hurried more than it would have been otherwise, and hasty work in cheese-making always means an increased loss of fat. Had the milk used been normal, as it comes from the cow, instead of having been made richer by the addition of cream, we think the loss of fat in the whey would have been much smaller.

For convenience we have rearranged in Table No. II, which follows, some of the data already given in the preceding pages.

TABLE No. II.

Showing the pounds of milk required to make one pound of cheese, the pounds of cheese made from one pound of fat, and the loss of fat, casein and albumen during the process of manufacture.

Number of cheese.	Per cent fat in milk.	Pounds milk required to make one pound green cheese.	Pounds cheese made from one pound fat in milk.	Per cent fat in first whey.	Per cent lost of the original amount of fat in the milk.	Per cent of casein and albumen in the milk.	Per cent lost of original amount of casein and albumen in the milk.
1	1.75	12.62	4.39	.15	7.7	3.72	19
2	2.49	11.16	3.59	.17	6.3	2.88	24
3	3.07	10.85	3.00	.17	4.9	3 05	23
4	3.58	10.06	2.77	.13	3.4	2.70	22
5	4.05	10.11	2.44	.34	7.6	3.00	25
6	4.07	9.80	2.50	.28	6.2	3.03	22
7	4.20	9.17	2.59	.26	6.2	3.03	20
8	4.61	8.60	2.52	.38	7.4	2.94	24
9	4.98	8.55	2.34	.63	11.6	2.75	24
10	5.10	7.86	2.49	.54	11.6	2.89	25
11	5.45	8.34	2,20	.45	7.2	2.74	26
12	6.18	7.43	2.17	.43	8.1	2.99	25
13	6.81	7.64	1.92	.66	13.4	2.84	24
14	6.83	7.13	2.04	.33	4.2	2.94	22
15	8.40	6.01	1.97	.65	7.4	3.00	23

Comparing the first two columns of Table No. II, it will be seen that the number of pounds of milk required to make one pound of cheese gradually decreases as the per cent of fat in the milk increases; with three exceptions the decrease is very regular, but not proportionate to the increase in the per cent of fat in the milk. In making Cheese No. 5 more milk was required to make one pound of cheese than in making Cheese No. 4, although the per cent of fat in the latter case was less than in the former. There were two reasons for this; first, more fat was lost in the whey in making Cheese No. 5, and second, more casein was lost. With Cheese No. 10 less milk was required to make one pound of cheese than with Cheese No. 11, although there was less fat in the milk from which the former was made, and the loss of fat was considerably greater. This is explained by the fact that Cheese No. 10 contained over four per cent less moisture than Cheese No. 11. With Cheese No. 13 more milk was required to make one pound of cheese than with No. 12, undoubtedly due to the unusual loss of fat during the process of manufacture.

Referring to the third column it will be seen that the number of pounds of cheese made from one pound of fat decreases as the per cent of fat in the milk increases. This was to be expected, but the figures given will not enable the cheesemaker, who handles only normal milk, to draw correct conclusions, because it is evident that the number of pounds of cheese made from one pound of fat depends more upon the amount of casein in the milk than upon any other one thing. In the milk from which Cheese No. 1 was made, from which half of the fat was removed, there was considerably more casein in proportion to the fat than there would be in normal milk, while there is considerably less casein in proportion to the fat in those cases where cream was added to the milk to bring it up to the required standard. Consequently the pounds of cheese made from one pound of fat would with normal milk in all probabilitv be less than the figures given for the first four cheeses and more with the others.

The fourth and fifth columns show the per cent of fat in the first whey and the per cent lost of the original amount of fat that was in the milk. The per cent of fat in the second whey and press drip does not appear, as the actual loss of fat in these was so small as to be insignificant; it is shown in the tables preceding this. The per cent of fat in the first whey is greater in those cases where the milk contained a high per cent of fat, but it does not increase with any regularity as the per cent of fat in the milk increases. For example, in the whey from No. 1 the per cent of fat was 0.15, while in the whey from No. 4 the per cent of fat was only 0.13, although with No. 4 the milk contained over twice as much fat as did No. 1. Again, No. 5 was made from milk containing 4.05 per cent fat, and the fat in the first whey was 0.34, while with No. 14, which was made from milk containing 6.83 per cent fat, there was only 0.33 per cent fat in the first whey. There was an unusual loss of fat in the first whey from No. 9. The reason for this can be seen by referring to the detailed report of the process of manufacture of that cheese in Table No. I. The milk was very ripe, making it necessary to hasten the process, and the result was a heavier loss of fat than usual. The loss in the first whey from No. 15 is also heavier than it would have been otherwise, for the same reason. We are unable to explain the loss in the whey from No. 13. The milk was apparently in good condition and the process of manufacture was the same as with the others. Not only did the curd part with fat easily while in the vat, but the loss in the press drip was excessive, as will be seen by reference to the detailed report of that cheese. Some unusual condition must have prevailed, but what it was we are unable to say.

It would seem from a study of column four that the relative loss of fat in cheese-making does not depend primarily, or even secondarily, upon the per cent of fat that is contained in the milk from which the cheese is made. While the actual loss of fat increases slightly as the fat content of the milk increases, yet the per cent lost of the original amount of fat in the milk did not seem, in this experiment, to bear any direct relation to the per cent of fat in the milk. This is shown very clearly in the fifth column. Cheese No. 1 was made from milk containing 1.75 per cent fat and 7.7 per cent of the amount of fat in the milk was lost during the process of manufacture. No. 15 was made from milk containing 8.40 per cent fat, and but 7.4 per cent of the amount of fat in the milk was lost during the process of manufacture. No. 2 was made from milk containing 2.49 per cent fat and 6.3 per cent of the entire amount of fat was lost during the process of manufacture, while with No. 14, made from milk containing 6.83 per cent fat, but 4.20 per cent of entire amount of fat was lost. The greatest loss was with No 13, which parted with fat very readily as has already been pointed out. During the manufacture of this cheese 13.4 per cent of the original amount of fat was lost. The least loss was with No. 4, made from normal milk, the per cent of the original amount of fat lost being but 3.4.

We think the results given indicate that the proportionate loss of fat in the manufacture of cheese depends more upon the care and skill exercised during the process of manufacture than upon the per cent of fat in the milk from which the cheese is made, and that in case it is deemed advisable to manufacture cheese from milk containing a very high per cent of fat, even though cream be added to the milk to increase it, the skillful maker will not lose a relatively greater per cent of the total amount of fat than in making cheese from milk from which a portion of the fat has been removed. There does not seem to be any foundation for the statement often made, that after the fat in the milk has passed three or three and one-half or four per cent the excess is lost in the whey.

The composition of the cheese as effected by the composition of the milk is shown very clearly in the series of tables given for the different cheeses made. This point will be discussed when the full report upon the cheeses is made.

Attention is called to the heavy loss of casein and albumen during the process of manufacture. It is shown in the last two columns of Table No. II. The average amount lost of the original amount of casein and albumen in the milk was about 23 per cent. It will be seen that the loss varied as much as six per cent, but no facts were brought out during the course of the investigation that enable us to account for this variation. This loss, as well as several other matters that have been brought to our attention during the investigation, will be studied in the future.

One of the main objects in conducting this investigation was to determine in so far as possible the relation the amount of fat in the milk from which the cheese is made bears to the curing of the cheese. Careful data is being kept in this connection, and as some of the cheeses are four months old, a report could be made at this time, but it is thought best to reserve the report of this part of the work until the experiment is discontinued. The cheeses will be sampled at different times by experts, and each one scored as closely as possible, according to its actual market value. We can not place the cheese upon the market for the reason that the numerous samples taken for analysis would debar it, but we hope in the way indicated to be able to determine quite closely the price at which each cheese would sell. This will give us some indications as to the amount of fat that should be in the milk to yield the cheese maker the greatest remuneration for his labor.